Auditory feedback in VR and HCI

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We call auditory feedback the feedback generated in response to a subject gesture when performing an action, and perceived by the subject's or the auditor's auditory perception [→ Auditory perception].

Auditory feedback in ecological environment

In our daily life we use sounds:

- to get information from the environment: what things are, where things are, where things are, when something happens.
- and to inform the environment about our actions or intentions: what we are doing, where we are doing it, when we are doing it. This includes verbal communication.

Research in ecological acoustics [Gaver, 1993] demonstrate that auditory feedback can in particular effectively convey information about a number of attributes of vibrating objects, such as material, shape, size, and so on. In fact the information that can be extracted from the auditory feedback concerns both the nature of the sources involved (size, material and mass) and the action performed (speed, acceleration, force) [Gaver, 2005].

Auditory feedback is commonly used in everyday life for human interaction with the world: actions very often generate sounds that are informative about them. The generated sound is fed back to the auditory system and allows deeper monitoring of the action itself.

Auditory feedback and action/gesture

In natural environment, sound/auditory feedback and actions are related in a number of different ways.

First, when sounds are generated externally, as those produced by autonomous sources (water falls, birds, wind, machines, etc.), they indicate, by themselves, what the objects that produced the sounds are, and where they are. The only auditory feedback that can be obtained in response to action is by moving our body or our head. In that case, there is obviously no relation between the physical properties of the objects that produce the sounds and our body. But the body plays the important role of a point of view that transforms the sound perceived without transforming the acoustic waves themselves.

Sound/auditory feedback can also be produced directly by action, when physically manipulating a physical object [→ Ergotic / epistemic / semiotic (...) loops]. In this case, there is a physical energetic consistency between action and produced sounds: sounds can be produced by temporary object manipulation (the sound starts after the end of the action), or by continuous object manipulation (the sound continues during the manipulation). In other words, the sound properties can encode the physical gestures at the same time as it encodes the physical nature of the object. We can say that the sound is the trace of the gesture on the matter, or of both the two interacting bodies and their interaction. There is more or less a sort of genuine physical consistency between the action and the produced sound.

Auditory feedback in digitalized environment

Most today's digitalized systems take into account only a few of the diverse, and precise features carried by auditory feedback in natural environment.

Apart in the special case of digital musical systems [→ Mapping, in digital musical instruments], the dominant paradigm is to trigger pre-

recorded sounds, then apply various sound processing algorithms [→ Sound algorithms]. With such a paradigm, the coupling of sound feedback to action is, very often, relatively relaxed.

For example, in virtual reality, one often use sound spatialization algorithms to provide the user with cues on sound source localization and sound propagation environment (room effects). The coupling to action is then mainly due to the movement of the subject's avatar in the environment, and to the triggering of sounds in case of various actions. Auditory feedback is also used to reinforce the user's feeling of immersion in the environment. An efficient mean to that aim is to compute spatialized auditory feedback in accordance with the subject's movement (by using a motion capture system), so that the sound sources apparently do not move in azimuth/elevation when the user moves his head.

In the human-computer interaction field, auditory feedback is used mainly for alarms, and more rarely for monitoring and status information [Brewster, 2002] [Kramer, 1994]. The coupling of auditory feedback to action is most often relaxed, at least due to the usually poor gesture device at hand (eg: a mouse, a keyboard…).

In the context of enaction, and in the light of embodied perception theories, developing enactive interfaces implies developing techniques for multimodal feedback and input, including sound, touch and gesture. Working on better coupling of gesture to auditory feedback allowing to close the perception-action loop in a continuous stream of information is, hence, a major research topic in the context of enactive interfaces. Toward that goal, various research directions are studied, including, but not limited to, ergotic interfaces [→ Interface, ergotic] that aim at respecting the energetic consistency of gesture and auditory feedback, physically-based modelling [→ Physically-based modelling techniques for sound synthesis], better gesture controllers and haptic devices.

References

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Related items

Auditory perception
Ergotic / epistemic / semiotic action-perception loops
Interface, ergotic
Mapping, in digital musical instruments
Perception, direct approaches: the ecological approach
Physically-based modelling techniques for sound synthesis
Sound algorithms